Introduction

The Robotic Development Board project entails producing a control board, a driver board, and needed electrical devices that can be implemented into multiple robotics projects. Our clients are a mechanical design group, in which we are partnering on the projects, and also for future groups that do not have the capability to develop the electrical side of a project. Our project will consist of:

- •Standing Wheelchair
- •Autonomous Snow Plow
- •H2 Fuel Cell Cart
- •Motorized Testbed Cart

The project will involve taking multiple inputs (joystick, gps, laser, etc). Using a microprocessor we can drive DC brushless motors, servo motors, and linear actuators based on our inputs.

Previous Works

Standing Wheelchair:

The standing wheelchair is not a new concept, but creating a standing wheelchair that better suits the needs of the user is always in development. Because of this, there are many different models of the standing wheelchair. The type of wheelchair we will be developing is fully automated and controlled using a type of joystick.

Superstand PS-2 Full Power Wheelchair

The Superstand PS-2 Full Power Wheelchair is a very similar design to what our design looks like. It has a fully powered system that is all controlled by a joystick. It runs

on two 12 volt batteries. The mechanical layout of this design already resembles the one that we have built. The chair even has a similar safety arm that functions as the chest support. Our goal is to produce something that has similar functions. That includes controls that allow the user to control their direction of movement, adjust the sitting or standing position, and control the safety arm.

LEVO C3

The C3 is a standing wheelchair produced by LEVO. It uses a more complicated 4 wheel drive to allow it to scale inclines and small obstructions more easily. The four wheel drive was also something we considered for the autonomous snowplow, but probably won't implement due to its over complications. The C3 has the functionalities of a regular standing wheelchair, but with a more off-road capabilities.

Autonomous Snowplow:

The designing of autonomous snowplows is a competition held each year in St. Paul, Minnesota. The competition is called the ION Autonomous Snowplow Competition. As it is the goal of our project to creating a snowplow to enter into this competition, the specs of our snowplow will meet the standards of the competition. Because of this, there are many previous works: the competitors in the previous competitions.

Ohio University's Monocular Autonomously Controlled Snowplow

The Monocular Autonomously Controlled Snowplow (M.A.C.S.) was an entry for the competition that has been developed by Ohio University Graduate and Undergraduate students. Ohio University has won the competition every year in the

competition's three year span. Their design uses a 360 degree monocular sensor to determine positioning. Unlike ours, their model did not use a GPS.

Hydrogen Fuel Cell Cart:

Hydrogen Car

Probably the main use of the hydrogen fuel cell has been its development for a hydrogen powered car. Replacing gas with hydrogen as a fuel source in cars would supposedly have dramatic benefits for the environment and cutting down on fossil fuels. We'd want to create something similar, but on a much smaller scale.

Motor Controller Development Board

Roboteq AX3500 Motor Controller

Roboteq's AX3500 controller is a product family designed to convert commands received from a R/C radio, Analog Joystick, wireless modem, or microcomputer into high voltage and high current output for driving one or two DC motors. The controller supports multiple modes of control like open loop and closed loop and sum and difference tank like control. This product incorporates many of the features that we would also like to include in our design.

Design Options

Microcontroller Selection

A microcontroller powerful enough to run several pulse-width modulation (PWM) channels for motor control. It needs several general purpose input/output pins (GPIO) for interfacing with the gps modules, laser range finder, Rx/Tx hobby radio ,and motor feedback signals. The controller needs to be inexpensive enough for our group to purchase several units. The power consumption is of minimal concern because performance and physical hardware is desired above the power requirements. Our initial inclination was to use a PIC based microcontroller because our group had previous experience using them in another class. In addition, our group is already familiar with the IDE and syntax used to program the PIC. This allows us to start programming earlier without the steep learning curve of learning a new microcontroller and its associated IDE.

Microchip dsPIC

Advantages:

- Discrete motor control PWM channels
- Two UART modules
- Free IDE
- Up to 70 MIPS
- PWM support for motor control: BLDC, BDCM, PMSM
- Designed with motor control applications in mind
- Group has some previous experience with PICs
- Extra GPIO ports which could be used if the design is expanded in the future
- Several ADC channels

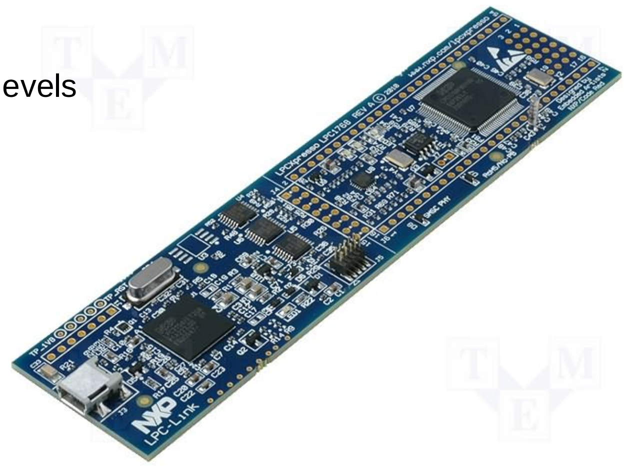
Disadvantages:

- There are many other options available to choose from which may work better in the design or may be easier to comprehend. The previous attempt at using a PIC as a microcontroller didn’t work as well as anticipated because it was too slow.Further in the design process, if we find that the dsPIC is not powerful enough or too complex to use, we may opt for another type of PIC or another brand of microcontroller such as an ARM or MSP430.

NXP LPC1769 Xpresso Microcontroller (ARM)

Advantages:

- Clock speed of 100MHz up to 120MHz
- 512kB of Flash
- 64 kB of memory
- 70 GPIO pins
- 10 timers that can operate on priority levels
- WAKE-UP for sleep mode
- USB interface
- Serial interfaces consist of:
  - 2-CAN
  - 4-UART
  - 3-I2C
  - 2-SSP
  - 1-I2S
- 8- 12-bit ADC
- 1- 10-bit DAC
- Free Compiler programs



Disadvantages:

- Exposed onboard parts require protection from electric shock, noise, dirt and moisture
- Code for the arm is still in C but is more complex than the PIC

We've chosen to go with the ARM processor, using the already designed dev board currently being used in the embedded systems II class. It has everything we need with extra GPIO pins for future use. The ARM will also run faster than the DsPIC from the extra flash and higher clock frequency. From previous use from the Mechanical Engineers, the PIC was too slow to operate the radar at its full potential. From the spec sheets, the ARM should be able to collect all the data needed for scans performed by the Laser Radar Sweep.

Motor Selection

The motors selected must be powerful enough to move the snow plow and plow snow simultaneously without stalling the plow. Additionally, the motors must be able to be driven from the motor driver without overloading the circuit. This is a substantial amount of power so our design will have to be heavy duty enough to safely control this power.

The mechanical engineering students will ultimately be responsible for choosing the specific motor. At this time they have provided us with the following details:

- Brushed dc motor type
- Power specifications are 48v with a maximum cummulative power of 3500W

Power MOSFET Selection

<u>MOSFET's</u>

Advantages

- Good for current amplification (voltage controlled, works well with logic)
- Small power loss across MOSFET
- Higher frequencies
- Relatively affordable

Disadvantages

- None

<u>IGBT's</u>

Advantages

- Can handle extremely high voltages

Disadvantages

- High priced

<u>Bi-Polar JunctionTransistors</u>

Advantages

- Good for current amplification (current controlled)

Disadvantages

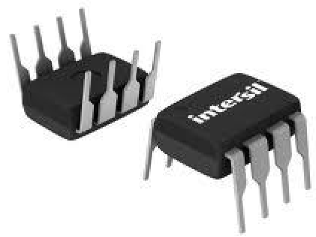
- Power loss across transistor

We've decided to use high power AOB482 MOSFETs in an H-bridge configuration for driving the dc motors. This MOSFET has been chosen because it conforms to the demands of the dc motors.

MOSFET Driver Selection

For driving the DC motors we will need a driver that steps up our 3.3V TTL pulse into a higher voltage to drive the gate of the Power MOSFET. To pick a driver you need to look at the gate capacitance and desired switching frequency. The drive must be able to supply a high current so the gate can charge up fast enough to match the switching speed and to cut down on switching losses by reaching the saturation stage, hence driving down the R_dson.

Intersil ICL7667



- Can take 3.3V in
- 4.5-15V out
- High peak output current

Power Supplies

For our project we need multiple power supplies:

- We will need a 3.3V supply on the control board for the ARM processor
  - Richtek RT9161-33GV
- We will need a 9V supply on the driver board to drive our power MOSFET gates
  - ST L78S09

Board Connectors

Headers

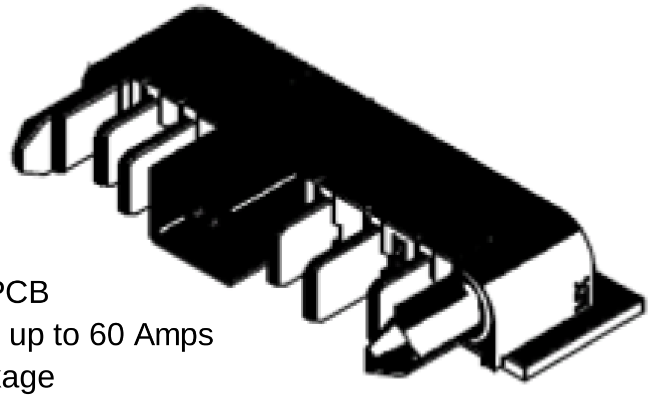
Advantages:

- Cheap
- Many connections
- Packages are in both horizontal and vertical mounting

Disadvantages:

- Pore packaging material
- Pin and bladed connections would require separate packages
- Cannot handle the weight from the modular board
- Pins can corrode
- Vibration can loosen the connecto

Molex Female/Male Connector



Advantages:

- Heat resistant
- 12 data pins and 5 power blades
- Screw holes for mounting to the PCB
- Each blade connector can handle up to 60 Amps
- Through hole surface mount package
- Male connector pins are horizontal and the female connector is vertically mounted
- Corrosion resistant gold plated connectors

Disadvantages:

- Cannot support the weight of the modular board
- Vibration can loosen the connection

We've decided to use the molex connector, it includes both pin and bladed connectors. The connector consists of 5 blades and 12 pin type connectors.The blade connectors are designed to handle up to 60 amps of current for each blade. With five pins, we can scale the voltage for each driver separately. There will consist a ground and the other four will be voltage taps which will allow the board to have a supply voltage of 12, 24, 36, or 48 volts. The pin type connectors are used for inputs and outputs which will allow the interface board to operate the modular driver boards. With the size and weight of the modular board, there will need to be a slot bracket which can hold the weight of the boards.

Development Board

It is important to pick a good design before beginning work on the Development Board. We need to be able to suite the needs of the mechanical engineering department and at the same time not over complicate the work required on our end. We've discussed several different options below.

Stacking the PCB's

Advantages:

- Smaller footprint for mechanical engineers

Disadvantages:

- More difficult to dissipate heat
- Difficult to insure board isolation

<u>Separating the interface board and controller board</u>
Advantages:
- Easier to troubleshoot
- Easier to change design during later phases of the project
- Costs less to replace one of the PCB's if it breaks

Disadvantages:
- Larger footprint
- Must incorporate a way to connect boards
- Having to manufacture 2 PCB's would increase PCB fabrication costs

<u>Combine interface board and controller board</u>
Advantages:
- Compact Design
- Reduce cost of PCB manufacturing

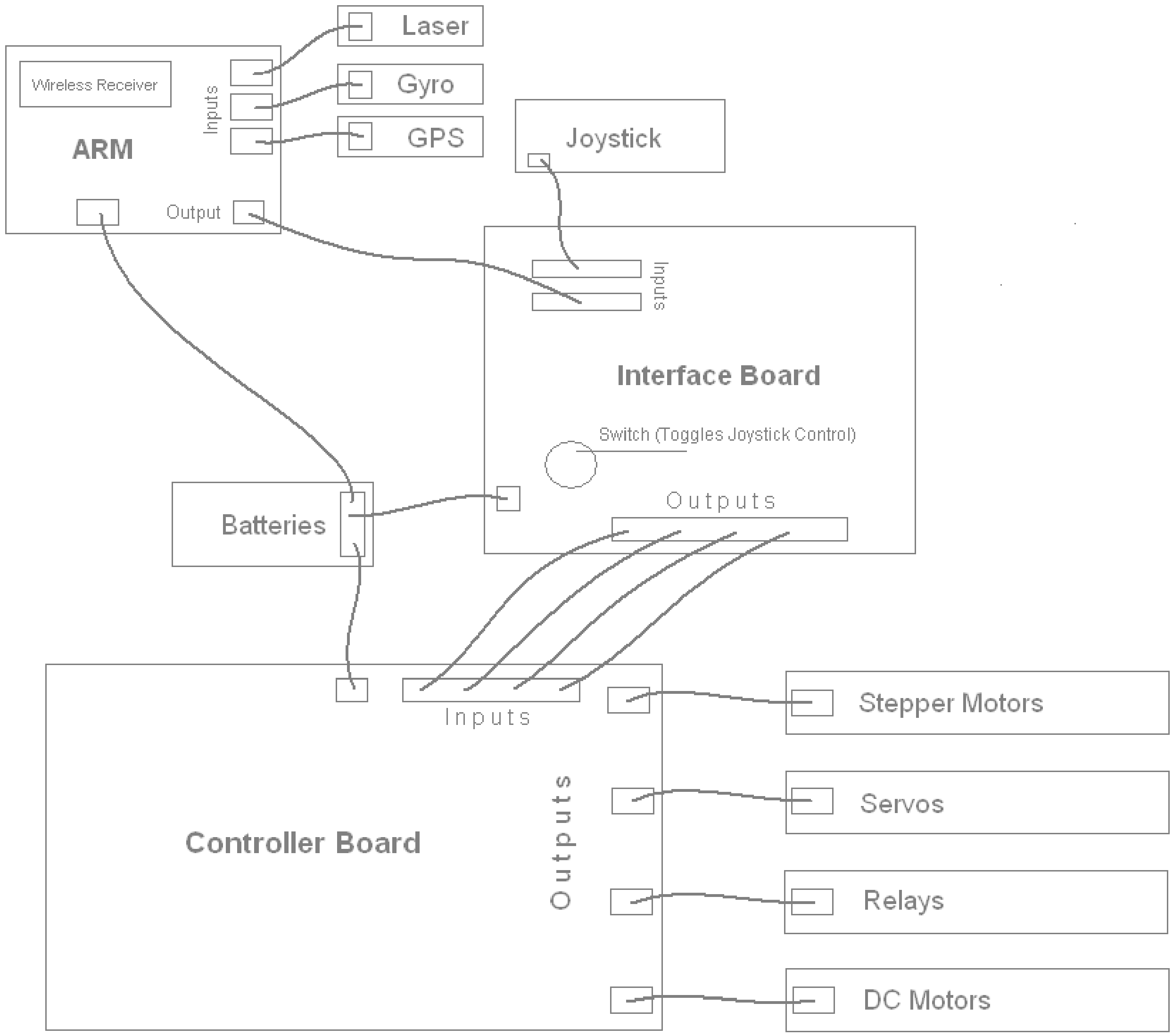
Disadvantages:
- More difficult to troubleshoot
- Costly to repair or replace
- Mixing high and low power circuitry
- Introduction of noise into the circuit components

<u>Implementing Ipad</u>
Advantages:
- Wireless control
- Intuitive tilt controls

Disadvantage:
- Expensive
- Time Consuming
- Unnecessary Complexity

We've decided to go with the separate interface and controller board design as shown in the figure below. We chose this design because it allows us greater flexibility if we need to make changes during later phases of the project. The PCB's will not be stacked, as the mechanical engineers do not require the smaller footprint that design would provide. We've also chosen to optionally (depending on time) include the Ipad implementation. In the budget we have allotted money for the purchase of a robotic Ipad controlled car, many of the components of the car such as the wifi receiver and the Ipad app itself will be used if we chose to implement Ipad control.

Preliminary Development Board Design:



Budget

	Count	Price	Total Price	Notes
Molex 46562-1079 connector	16	7.26	131.16	Interface board connector/ includes shipping for both molex connectors
Molex 46437-1079 connector	14	6.4	89.60	Modular board connector
NXT LPC 1769 ARM Controller	2	29.95	59.90	
AOB482 MosFET	40	1.89	75.60	
PCB Boards	4	35	220.00	Advanced Circuits/ shipping included
Ipad Rover	1	80.00	110.00	includes shipping
resistors/diodes /misc.		60.0	60.00	
Intersil ICL7667	6	5.74	34.44	
Heatsinks	8	≈ 10.00	80.00	10 Watt Dissipation
Belimo AMQX24-1	2	209.30	418.60	
Linear Actuator	1	300.00	350.00	Includes shipping
Ipad 16Gb	1	399.00	399.00	Free Shipping/Engraving
		Total	$2104.2	

Summary

After carefully reviewing all of our options we have come up with a sufficient and practical design which successfully meets the needs of the mechanical engineering department. The decisions we made reflect what we thought would work best, given the limited timeline and budget. Our goal for this project is to successfully create a robotic development board that can be implemented into multiple robotics projects without going over budget. We will spend the current and following semester designing, constructing, and troubleshooting our design. We have shown in our timeline that we plan to have a working prototype by the conclusion of our senior design.